

***Eurycercus (Bullatifrons) norandinus* (Crustacea: Branchiopoda: Eurycercidae), a new species of Cladocera in the Neotropical Region**

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Abstract

Eurycercus (Bullatifrons) norandinus **sp. nov.** is described from Lago de Tota, Boyacá, Colombia. It differs from other species of subgenus *Bullatifrons* in the lower number of denticles on the dorsal margin of the postabdomen, the lower number of denticles on the postadominal claw, and the higher number of denticles on scrapers 2, 3 and 4 of trunk limb II. Regression statistics comparing the new species with other species of the subgenus indicate that during ontogeny, the rate of increase in teeth number of the dorsal margin of the postabdomen in relation to postabdominal length is higher than in other species. With the present record, the distribution of *Eurycercus* expands to the central part of the Neotropical Region and that of subgenus *Bullatifrons* to South America.

Key words: taxonomy, benthic Cladocera, Andean lake, Lago de Tota, Colombia

Introduction

The genus *Eurycercus* Baird, 1843 is distributed in the Holarctic region, with individual reports from the Southern Hemisphere in South Africa, Argentina (Frey 1978) and Brazil (Montú & Gloeden 1986, cited by Elmoor-Loureiro 1997) (see Tab. 1). Until now, eight species of the genus are known whereas Dumont and Negrea (2002) affirm that this number could possible increase up to twelve. It has been demonstrated in cladocerans, that species initially considered cosmopolitan, have actually a more restricted distribution (Frey 1971, 1978, 1986; Hann 1982, 1989). Frey (1975) established 3 subgenera within the genus *Eurycercus*. One of them, *Bullatifrons*, includes four species with a holarctic distribution.

During a faunistic survey of the aquatic invertebrates of the high mountain Lago de Tota in the Andean Colombian Cordillera Oriental, a *Eurycercus* species was collected in the littoral zone between water weeds. Its morphological characteristics assign it to the subgenus *Bullatifrons* (morphology of the head median pore, labrum, as well as on the one-looped intestine).

As the genus *Eurycercus* was already known from Argentina, Brazil and Mexico, the discovery of this species in Colombia expands its distribution to the central Neotropical region. The most southern report of the genus in North America was Mexico City (Juday 1915; Elias-Gutiérrez *et al.* 1999) and the most northern in South America was Laguna de Patos, Rio Grande do Sud, Brazil (Elmoor-Loureiro 1997).

Material and methods

Samples were collected between January and February 2004 at the littoral zone of Lago de Tota, using a standard zooplankton net (mesh size 80µm). Samples were fixed with formaldehyde (final concentration

approx. 4 %). 44 parthenogenetic females were selected and dissected, following the technical instructions given by Dumont and Negrea (2002). Specimens were mounted in glycerol or polyvinyl-lactophenol. In order to study the taxonomy of the species and to evaluate intra- and inter-specific variability, 14 morphological features were analysed following Frey (1973, 1975) and Hann (1982). Measurements were done using a micrometric ocular mounted in an Eclipse E 200 Nikon microscope and in a U-BH Rossbach microscope. Specimens were selected randomly across all development stages.

The morphological similarity with the other species of the subgenus *Bullatifrons* was studied with a cluster analysis, using the program Statistica 7. Euclidean distances were applied as measurement of similarity and the technique of the nearest neighbour as clustering method. A regression analysis with Statgraphics Plus 2.0 was applied to study morphometrical and meristic relationships. With that purpose, we selected body length (BL) and postabdominal length (PL) (Frey 1973) as independent variables. Illustrations were carried out using a drawing tube mounted on Carl Zeiss – Jena microscope. Terminology follows Fryer (1963) and Frey (1975), and taxonomy Dumont and Negrea (2002).

TABLE 1. Geographic distribution of the species of *Eurycercus*.

Subgenus	Species	Distribution	Reference
<i>Bullatifrons</i>	<i>longirostris</i>	North America	Hann (1982)
	<i>macrocanthus</i>	Siberia	Frey (1973)
		Sweden	Frey (1975)
	<i>norandinus</i> n. sp.	Colombia	present record
	<i>pompholygodes</i>	Sweden	Frey (1975)
	<i>vernalis</i>	North America	Hann (1982)
<i>Eurycercus</i>	<i>lamellatus</i>	North America	Frey (1973)
		Europe	Flößner (2000)
		Asia, Tibet	Frey (1971)
		Algeria	Frey (1971)
		South África	Frey (1978, 1986)
		Brazil	Elmoor-Loureiro (1997)
		Argentina	Frey (1978, 1986)
		North America	Frey (1978)
		México	Juday (1915)
		Denmark	Frey (1973)
<i>Teretifrons</i>	<i>glacialis</i>	Ireland, Scotland	Flößner (2000)
		Germany, Netherlands	Flößner (2000)
		Canada, Russia	Hann (1989)
	<i>nigracanthus</i>	Canada	Hann (1989)

Results

Taxonomy

Family Eurycercidae Kurz, 1875

Subfamily Eurycercinae Kurz, 1875

Genus *Eurycercus* Baird, 1843

***Eurycercus (Bullatifrons) norandinus* sp.nov.**
(Fig. 1–2)

Type locality: Lago de Tota, State of Boyacá, Colombia (5°32' N, 72°55' W) at 3015 m.a.s.l., littoral zone, mainly covered by the aquatic plant *Egeria densa*.

Material examined: all are parthenogenetic females. No males were found in the samples.

Holotype: female, collected the 14.02.2004, total length 1.93 mm, mounted in glycerol and deposited at the Museo de Historia Natural, Instituto de Ciencias Naturales, Universidad Nacional de Colombia (ICN-MHN-CR 2495).

Paratypes: 1 female, mounted in glycerol on slide (ICN-MHN-CR 2496) and 8 females, undissected, preserved in ethanol (ICN-MHN-CR 2497), collected the 14.03.2004; 8 females, mounted in slide with polyvinyl lactophenol, deposited at the Naturhistorisches Museum Wien (NHMW 22987 to 22894), collected the 23.01.2004; 26 females undissected, preserved in ethanol, deposited at the Museo de Historia Natural, Universidad Pedagógica y Tecnológica de Colombia (UPTC-MHN-ART 0001).

Etymology: the name of the species refers to the geographical zone of the Cordillera de Los Andes where the material was collected.

Diagnosis. *Eurycercus (Bullatifrons) norandinus* show the lowest number of teeth of the dorsal margin of the postabdomen (mean 81.4 \pm 4.9 SD, range 73–92) and the lowest number of denticles at the postadominal claw (33.0 \pm 4.8 SD, range 20–40) despite of its bigger size compared with the other 4 species of the subgenus *Bullatifrons*. On the contrary, it show the highest number of denticles of setae (called also scrapping spines by Fryer 1963) 2 (mean 18.8 \pm 2.8 SD, range 12–23), 3 (19.8 \pm 2.8 SD, range 14–24) and 4 (20.8 \pm 1.7 SD, range 18–24) of the corm of the trunk limb II, compared with the other 4 species.

Applying descriptive statistics to analyse morphological and meristical traits of individuals of the population, it is show that during ontogeny the rate of increase in teeth number of the dorsal margin of the postabdomen in relation to the postabdominal length is higher than in the other species. *Eurycercus norandinus* shows the lowest correlation coefficients between the length of postabdomen and the number of marginal and proximal spinules on the internal lobe of trunk limb I (Tab. 4). Likewise the increment of the number of these spinules in relation to the increment of the postabdominal length is the most regular (Fig. 4C, D).

Description. *Shape:* in lateral view dorsal margin of carapace weakly arched, interrupted only by the bubble-like section of the head pore. Ventral margin anteriorly concave and its anteroventral margin weakly angled (Fig. 1, A).

Size: total length 1.93 mm, maximal height of the carapace 1.19 mm.

Head: rostrum short, not surpassing in length the insertion point of the sensorial seta of the antennule, sharpen in lateral view, head as long as broad. Median head pore (main pore) projected as a bubble of 30 μ m diameter. Distance between the lateral head pores (minor pores) 48 μ m (Fig. 1, A and C).

Antennule (Fig. 1, B): with convex anterior margin, elongated, the lateral sensorial seta inserted in the median part, with 9 terminal sensorial setae.

Antenna: with characteristic morphology of *Eurycercus*, both articles 3-segmented. Exopodite with three, endopodite with five swimming setae.

Labrum: weakly developed, with gently rounded anterior border, without anterior and posterior marginal extensions (Fig. 1, D).

Trunk limb I (Fig. 1, E and F): internal distal lobe (IDL) with three 2-segmented clasping hooks, first and third hook longer than median one, with segments articulated allowing movement to one other, second hook with fused segments (limit between former segments can be noted); median hook more curved than the others; second segment of first and third hook with a row of hairs along the concave edge, median hook with row of hairs at the proximal section of the second segment. Basal segment with three clusters of spines: distal cluster and proximal clusters with 8 long spines each one, marginal cluster with 6 short spines; in addition, irregular clusters of very small spinules inserted near the proximal cluster, and a semicircular patch of grinding tubercles near the base of the lobe (Fig. 1, F). Outer distal lobe (ODL) with 2-segmented setae, the outer one shorter than the first segment of the internal seta.

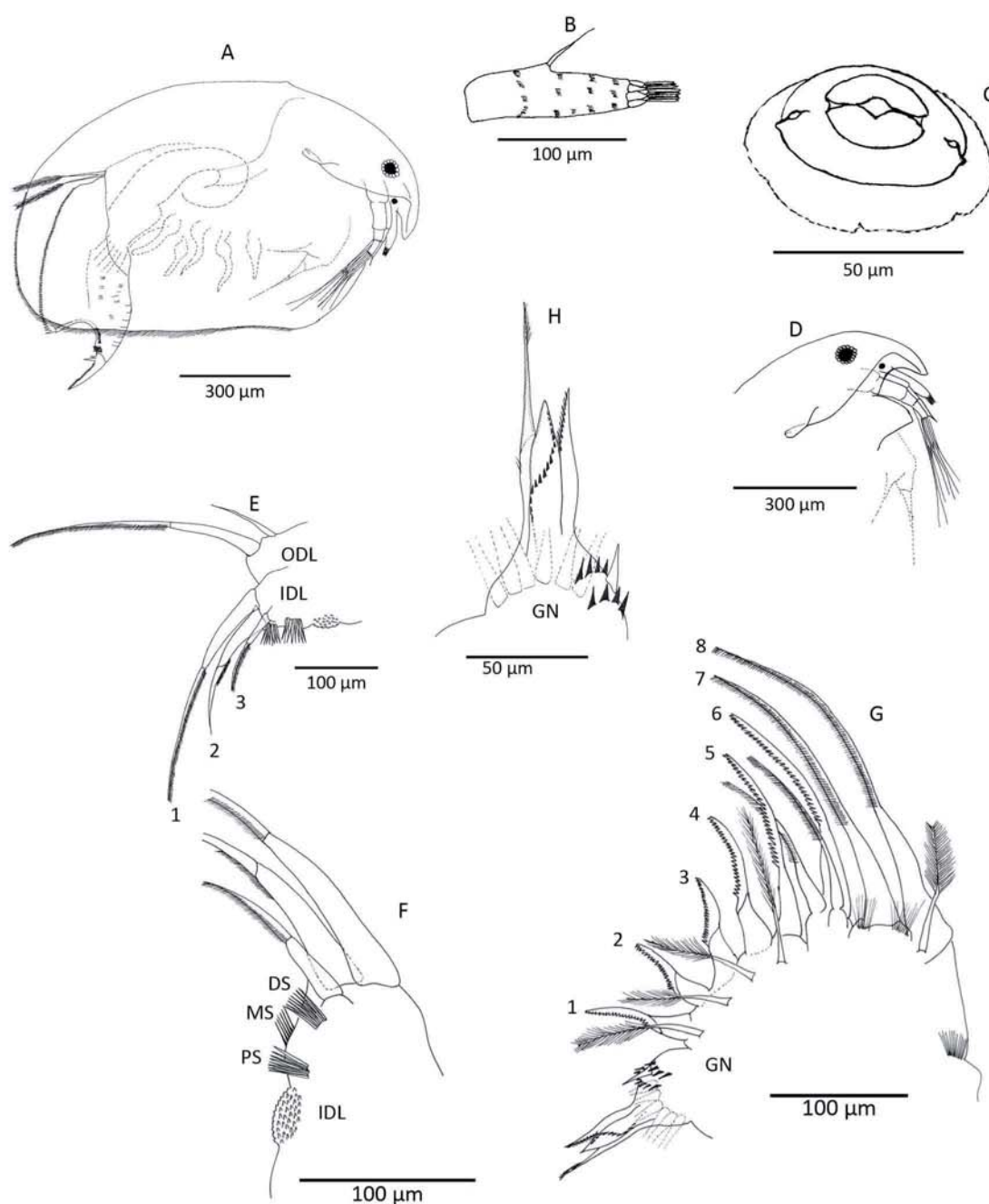


FIGURE 1. *Eurycercus (Bullatifrons) norandinus* n.sp., holotype female. A, parthenogenetic female; B, antennule; C, headpores; D, headshield with antennula, antenna and labrum; E, trunk limb I, exopodite, lateral view (corm not shown); F, trunk limb I, exopodite, inner distal lobe; G, trunk limb II, exopodite; H, trunk limb II, gnathobase. DS, distal spinules; GN, gnathobase; IDL, inner distal lobe; MS, marginal spinules; ODL, outer distal lobe; PS, proximal spinules.

Trunk limb II (Fig. 1, G and H): consists of gnathobase and corm (fused body of the trunk limb), each with a variety of setae and scrapers. Gnathobase pyramidal, with 3 terminal appendages, anterior one with hairs along its axis, median shorter and with distal denticles, posterior longer and with lateral teeth up to its end. Distal edge of gnathobase with one robust spine and two series of spinules near its base (Fig. 1, H). Filter plate with 7 feathered setae, the most proximal stronger than the others. Feathered setae 5 and 6 inserted more distal than feathered setae 1–4 and 7. Corm with 8 robust scrapers, bearing denticles in the concave distal margin of each one. Scrapers 2 to 4 with 19, 22 and 23 denticles respectively.

Trunk limb III (Fig. 2, A and B): exopodite with 8 setae, the disposition of the 5 distal setae typical of subgenus *Bullatifrons*, with exception of the third one, which is slightly bent (Fig. 2, A). Gnathobase

consisting of 3 apical setae of different length and structure, like in the other species of the subgenus, and bearing a filter, constituted by 9 setae (Fig. 2, B).

Trunk limb IV (Fig. 2, C): exopodite consisting of a big lamella with 8 setae, posterior seven setae feathered with filtering function, nearest seta to the gnathobase not feathered. Gnathobase with a group of 4 setae of variable length, the outer one more sclerotized than the others and without setules, with one strong spine inserted near the base of the inner seta, apical edge with a long geniculated sensilla and a bifurcated short and robust seta. Lateral surface of gnathobase with 3 clusters of spines, distal cluster and proximal clusters with 8 long spines each one.

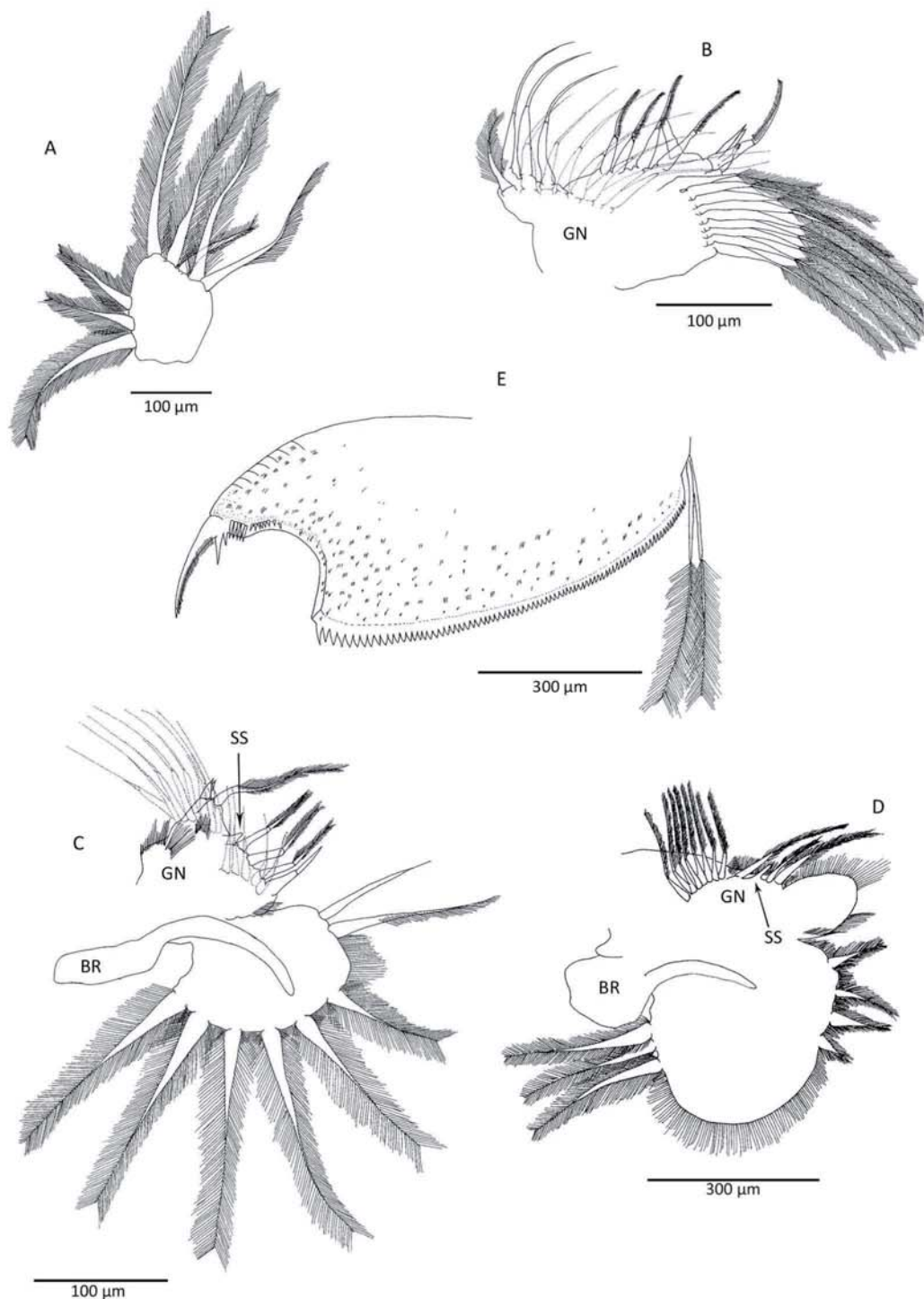


FIGURE 2. *Eurycercus (Bullatifrons) norandinus* n.sp., holotype female. A, trunk limb III, exopodite; B, trunk limb III, gnathobase; C, trunk limb IV, exopodite; D, trunk limb V, exopodite; E, postabdomen with postabdominal claw. BR, branchial plate; GN, gnathobase; SS, sensilla.

Trunk limb V (Fig. 2, D): exopodite consisting of a big, flattened lamella with 7 feathered setae in total separated in two groups, 3 being longer and “soft” and 4 shorter and “hard”. Gnathobase with a filter plate consisting of a group of 8 setae of similar size and structure, apically with a group of 3 feathered setae, the median being shorter than the others, with a sensilla between proximal and median setae.

Trunk limb VI: triangular flattened plate, rounded ventrally with dense fringe of long setae along anterior margin. As in *E. macrocanthus* it presents a finger-like process arising from de bract.

Postabdomen (Fig. 2, E): total length 604 μm , dorsal margin slightly curved, with a row of 82 teeth, increasing proportionally their size until the posterior region. Lateral surface covered with clusters of small spinules increasing in size distally.

Postabdominal claw: length 158 μm , with two strong spines on its base, the distal one longer than the proximal, additionally with two rows of spines with 5 long and 8 short spines respectively; concave edge of claw with a proximal row of 20 small denticles and a distal row with 16 denticles of major size.

Variability in intra-specific morphology. Fourteen morphological variables within the studied population of *Eurycercus norandinus* are shown in table 2. The length of cephalic shield and body length presented the highest variation, with coefficients of 28.4 % and 28.0 % respectively. The number of denticles on the postabdominal margin and on the fourth seta of trunk limb II showed the lowest variation. The length-frequency distribution of the body size of the (44) individual studied is presented in Fig. 5. The minimal body length of a female with evidence of maturity (carrying eggs female) was estimated with 1.43 mm. Developing instars IV and V were differentiated, although instars I to III could not be separated between them. It was noted meristical variability in the clusters of the spines of the basal segment of the internal lobe of limb I: paratype NHMW 22888 carries 6 spines on the distal cluster, 9 in proximal cluster and 5 in marginal cluster, while paratype NHMW 89 carries 9, 10 and 6 spines and paratype NHMW carries 8, 10 and 4 spines, in contrast to holotype with 8, 8 and 6 spines respectively.

Caption of Table 2 correspond to Table 3

TABLE 2. Morphometric characteristics of *Eurycercus norandinus* (n=44). Data from *E. macrocanthus* from Frey (1973), *pompholygodes* from Frey (1975), *longirostris* and *vernalis* from Hann (1982).

Variable	Range	Mean	Standard deviation	Variation coefficient (%)
Body length (μm)	683 to 2090	1367.3	383.0	28.0
Headshield length (μm)	336 to 998	673.7	191.3	28.4
Length of postabdomen (μm)	278 to 722	539.6	133.7	24.8
No. of postabdominal teeth	73 to 92	81.4	4.9	6.0
Length of postabdominal claw (μm)	77 to 178	138.2	34.6	25.0
No. of denticles on postabdominal claw	20 to 40	33.0	4.8	14.6
No. of proximal spinules of trunk limb I	5 to 9	7.2	1.3	17.9
No. of distal spinules of trunk limb I	5 to 9	6.9	1.1	15.7
No. of marginal spinules of trunk limb I	4 to 6	5.4	0.7	12.3
No. of denticles of scrapping spine 2 of trunk limb II	12 to 23	18.8	2.8	15.9
No. of denticles of scrapping spine 3 of trunk limb II	14 to 24	19.8	2.4	11.9
No. of denticles of scrapping spine 4 of trunk limb II	18 to 24	20.8	1.7	8.3
Diameter of median head pore (μm)	15 to 32.5	25.0	4.7	18.8
Distance between lateral head pores (μm)	25.3 to 55	41.1	8.8	21.4

Differential diagnosis. Characters unique to the subgenus *Bullatifrons* and present in *Eurycercus* (*Bullatifrons*) *norandinus* are the morphology of the head pore which is projected like a bubble, the weakly expanded keel of the labrum lacking a prominent apex and the one-looped intestine.

Differential diagnosis of the species of *Eurycercus* (*Bullatifrons*) included the study of morphological and meristic traits of several animals of the population, compared with the other species of the subgenus (Tab. 3 and 4, Fig. 3 and 4).

Eurycercus norandinus tend to have a bigger body size (mean value 1.37 mm, n = 44) than the other species of the subgenus (*longirostris* 1.35 mm, n = 518; *vernalis* 1.32 mm, n = 526; *pompholygodes* 1.30 mm, n = 159; *macrocanthus* 1.26 mm, n = 117). See table 2 and 3.

Ratio of head size in relation to the body size smaller in comparison with *Eurycercus macrocanthus*, higher in respect to *Eurycercus pompholygodes* and almost similar to *Eurycercus longirostris* and *Eurycercus vernalis*.

Caption of Table 3 correspond to Table 2

TABLE 3. Comparative morphology of the species of *Eurycercus* (*Bullatifrons*). Scrapping spine refers to the setae of trunk limb II (Fryer 1963).

Variable	<i>E. macrocanthus</i>	<i>E. pompholygodes</i>	<i>E. longirostris</i>	<i>E. vernalis</i>	<i>E. norandinus</i>
Body length (μm)	1258	1302	1351	1321	1367
Length of postabdomen (μm)	501	556	437.7	427.2	539.6
Headshield length (μm)	499	74	656.6	646.7	673.7
Length of postabdominal claw (μm)	122	129.3	147.6	138.1	138.2
No. of denticles on postabdominal claw	38.4	44.7	37.4	34.8	33.0
No. of postabdominal teeth	84.5	90.4	93.3	95	81.4
Diameter of median head pore (μm)	-	21.6	24.5	24.8	25.0
Distance between lateral head pores (μm)	-	34.2	47.1	41.3	41.1
No. of proximal spinules of trunk limb I	-	7.6	6.9	7.1	7.2
No. of distal spinules of trunk limb I	-	5.6	6.3	6.9	6.9
No. of marginal spinules of trunk limb I	-	5.9	4.8	4.3	5.4
No. of denticles of scrapping spine 2 of trunk limb II	13	14.9	14.8	15	18.8
No. of denticles of scrapping spine 3 of trunk limb II	11	15.4	15.5	15.7	19.8
No. of denticles of scrapping spine 4 of trunk limb II	12.7	17.2	17.8	17.4	20.8

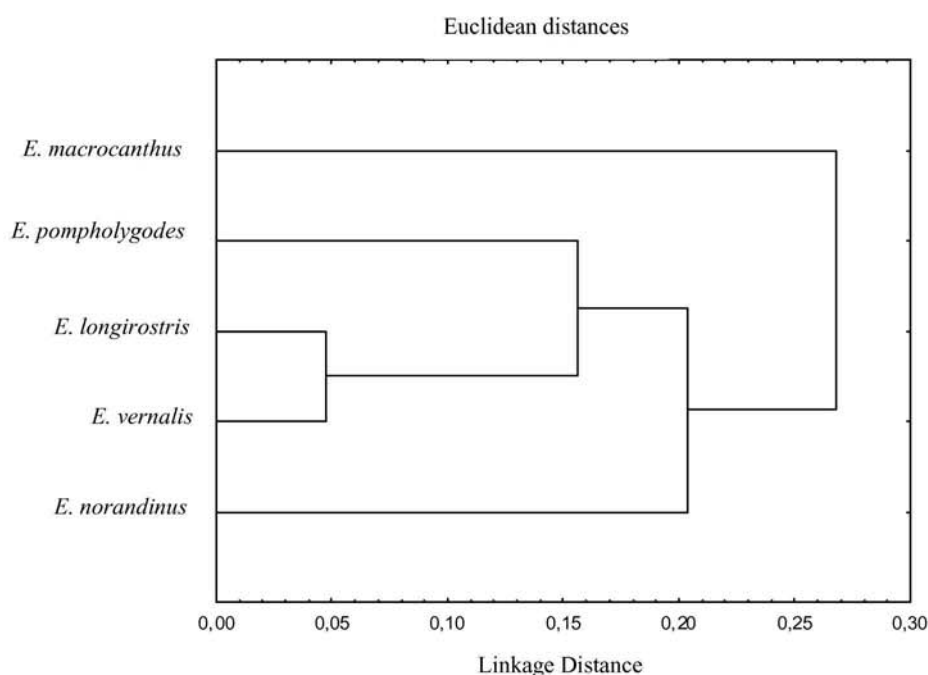


FIGURE 3. Dendrogram showing the grouping of the species of *Eurycercus* (*Bullatifrons*) based on the degree of similarity of 14 morphological traits (based on table 3).

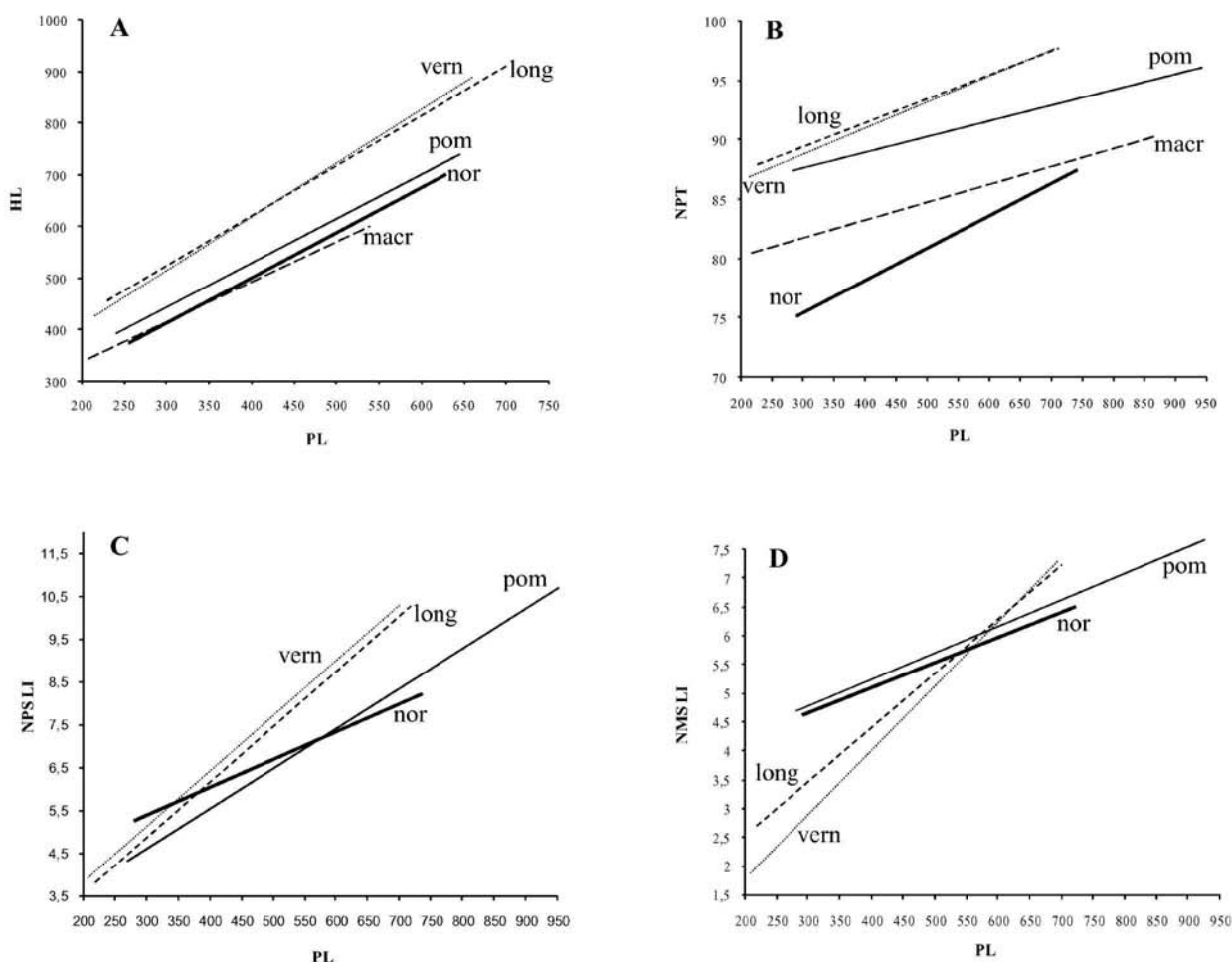


FIGURE 4. Regression lines of A, length of the headshield HL; B, number of postabdominal teeth NPT; C, number of proximal spinules of trunk limb I NPSLI, and D, number of marginal spinules of trunk limb I NMSLI, versus postabdominal length PL, in the species of *Eurycercus* (*Bullatifrons*). vern = *vernalis*, long = *longirostris*, pom = *pompholygodes*, nor = *norandinus*, macr = *macrocanthus*.

The comparative study of 6 morphological traits (length of the body, headshield, postabdomen and postabdominal claw, diameter of median head pore, distance between lateral head pores) and 8 meristical traits (number of postabdominal teeth, number of denticles on postabdominal claw, number of spinules of proximal, distal and marginal clusters of trunk limb I, number of denticles of scrapers 2, 3 and 4 of trunk limb II) of the 4 known species and the new species, determines a strong morphological similarity between *Eurycercus vernalis* and *Eurycercus longirostris*.

The species *Eurycercus pompholygodes* associates to a minor degree with that group. *Eurycercus norandinus* and, in a higher degree, *Eurycercus macrocanthus* move away from the mentioned group. The differences to *Eurycercus pompholygodes* refer mainly to the shorter cephalic shield of *Eurycercus norandinus*, fewer denticles on the postabdominal claw, a larger diameter of the median cephalic pore and a greater distance between the lateral pores, likewise the new species presents a higher number of denticles on scrapers 2 to 4 of trunk limb II. Nevertheless, these two species present the major length of postabdomen (mean values: *pompholygodes* 556 μm , $n = 34$; *norandinus* 534 μm , $n = 44$) and of cephalic shield (mean values: *pompholygodes* 754 μm , $n = 34$; *norandinus* 674 μm , $n = 44$), compared to the other 3 species of the subgenus, which explains the slight association between them.

The regression statistics applied shows differences in the calculated slopes for each relation of variables (length of the cephalic shield, number of postabdominal teeth, number of proximal spinules of trunk limb I and number of marginal spinules of trunk limb I, all in relation to postabdominal length) of the species of *Eurycerus* (*Bullatifrons*). The species *Eurycerus longirostris* and *Eurycerus vernalis* show a similar trend in the majority of relations. The rate of increment of the cephalic shield in relation to the length of postabdomen during ontogeny is higher in both species, followed by *Eurycerus norandinus*, *Eurycerus pompholygodes* and *Eurycerus macrocanthus* (Tab. 4).

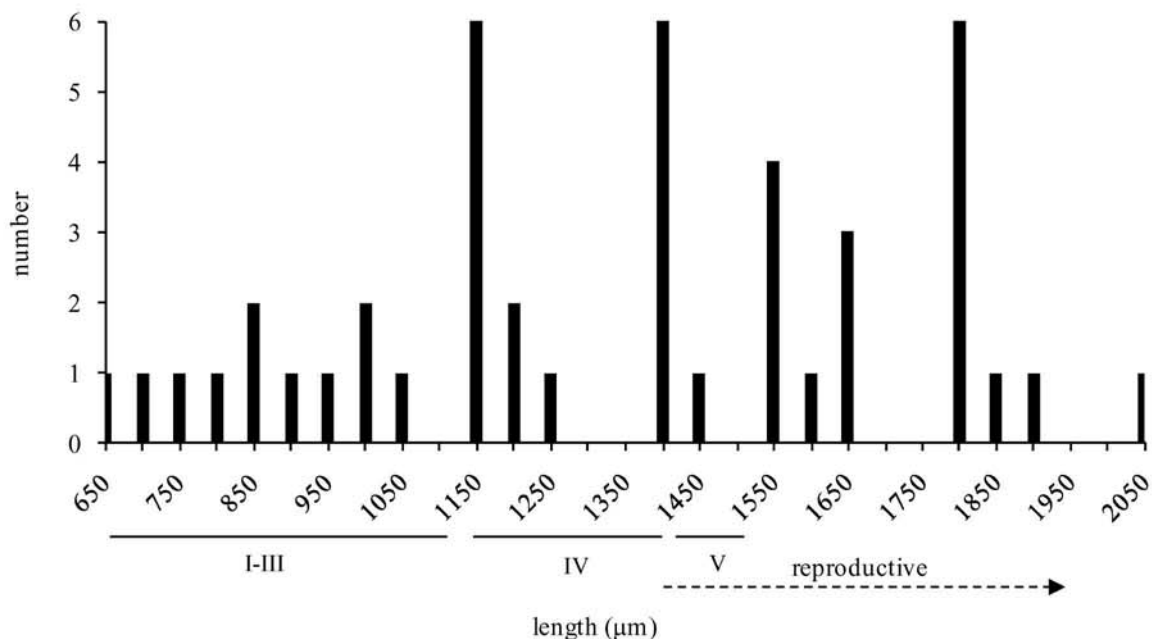


FIGURE 5. Length-frequency distribution of the studied specimens ($n = 44$) of *Eurycerus* (*Bullatifrons*) *norandinus* n. sp. Development instars I–III, IV, V and eggs carrying females (reproductive) are indicated.

The difference in the trends per species accentuates in the relation between postabdominal length and number of teeth on its edge. *Eurycerus norandinus* shows the lowest number of teeth despite of its relatively big size within the species of the sub-genus (Tab. 3) and the highest rate of their increment in relation to the postabdominal length (Fig. 4, B). That trend is also observed in the amount of denticles of the relatively big postabdominal claw.

Remarks. The discovery of a new species of *Eurycerus* in Lago de Tota suggests a long isolation of the lake and in general of high-andean lakes, which could have resulted in speciation. This has been observed in copepods like in *Metacyclops leptopus totensis* (Reid *et al.* 1990) from the same lake, in *Tropocyclops prasinus altoandinus* (Gaviria 1994) or in the genus *Colombodiaptomus*, which is distributed in a restricted area of the high-plane of the Cordillera Oriental (Gaviria & Aranguren 2007).

It is recommended to study the populations of *Eurycerus* found in lakes of Cundinamarca state in Colombia (H. Dumont & S. Gaviria, pers. obs), that probably belong to the same species, and to determine their intra-specific variation.

With the discovery of *Eurycerus* (*Bullatifrons*) in Colombia, the distribution of the subgenus extends from the northern Palearctic (*E. macrocanthus* and *E. pompholygodes*) and eastern North America (*E. vernalis* and *E. longirostris*) to northern South America (*Eurycerus norandinus*). To date, the only evidence of the presence of the genus in South America were reports of *Eurycerus lamellatus* in Argentina (Frey 1973) and in Brazil (Elmoor-Loureiro 1997). It is strongly recommended to revise the taxa in both localities, as they will likely turn out to be different from *Eurycerus lamellatus* sensu stricto, as suggested by Frey (1986).

TABLE 4. Regression statistics for the species of *Eurycercus* (*Bullatirifrons*).

Regression	Variable x	Variable y	<i>E. macrocanthus</i>			<i>E. pompholygodes</i>			<i>E. longirostris</i>			<i>E. vernalis</i>			<i>E. norandinus</i>		
			n	Corl.	Slope	n	Corl.	Slope	n	Corl.	Slope	n	Corl.	Slope	n	Corl.	Slope
1	BL	PL	117	0.992	0.4094	159	0.9945	0.4087				44	0.869	0.326	44	0.869	p<0.001
2	PL	HL	19	0.92	0.9697	34	0.9752	1	518	0.9497	1.298	526	0.9518	1.357	44	0.588	1.097
3	PL	LPC	44	0.994	0.2493	130	0.9914	0.226	520	0.8712	0.301	497	0.8381	0.305	44	0.928	0.249
4	PL	NPT	68	0.6	0.0209	174	0.387	0.0143	511	0.2775	0.026	546	0.2228	0.024	44	0.531	0.027
5	PL	DiaMP				35	0.4281	0.0058	514	0.085	0.006	556	0.1168	0.007	39	0.598	0.03
6	PL	DisLP				35	0.7458	0.0364	517	0.7034	0.082	540	0.7052	0.061	39	0.837	0.066
7	PL	NPSLI				85	0.7955	0.0107	233	0.6263	0.015	262	0.6921	0.015	43	0.47	0.007
8	PL	NDSLI				85	0.5151	0.0035	233	0.4971	0.008	262	0.4531	0.01	43	0.476	0.006
9	PL	NMSLI				82	0.5241	0.004	231	0.5454	0.009	254	0.4652	0.01	42	0.416	0.003
10	PL	NDS2LII				107	0.0742	0.0007	214	0.6225	0.014	254	0.7456	0.023	43	0.479	0.015
11	PL	NDS3LII				106	0.0563	-0.0008	216	0.4102	0.009	257	0.6688	0.02	43	0.432	0.012
12	PL	NDS4LII				102	0.3746	-0.0049	207	0.2068	0.007	255	0.5705	0.018	43	0.263	0.007

BL: Body length, PL: Length of postabdomen, HL: Headshield length, LPC: Length of postabdominal claw, NPT: No. of postabdominal teeth, DiaMP: Diameter of median head pore, DisLP: Distance between lateral head pores, NPS LI: No. of proximal spinules of trunk limb I, NDS LI: No. of distal spinules of trunk limb I, NMS LI: No. of marginal spines of trunk limb I, NDS2 LII: No. of denticles of scraping spine 2 of trunk limb II, NDS3 LII: No. of denticles of scraping spine 3 of trunk limb II, NDS4 LII: No. of denticles of scraping spine 4 of trunk limb II.

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